◇ Monograph Excerpt ◇

Matter Antimatter Fluctuations

search, discovery and analysis of Bs flavor oscillations

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Preface

The quest to discover the fundamental laws of nature is an inalienable endeavor of humankind. The undertaking being carried forward through several distinct avenues, it befits particle physics to aim at disclosing the secrets of the universe at the most elementary level. The most sophisticated probes on earth, the particle accelerators and associated detectors, constitute the tool employed in the discovery process. The discipline has achieved a grand synthesis over the last decades now codified in the elegant theory known as the standard model. Notwithstanding the model continuing to be gratified by countless experimental confirmations, theoretical shortcomings and recent cosmological data have had it rehashed as an insufficient formulation. The discovery of what new physics may lie beyond, being pursued in a multitude of paths, has become the paramount goal of the field.

This book presents and explicates the search and ultimate observation of the quantum-mechanical mixing between matter and anti-matter states in an intriguing subatomic particle system. The analysis of the rapid-fire transitions constitutes a high-sensitivity probe of nature's fundamental mechanisms, constraining the standard model and potential new physics descriptions. The phenomenon and its measurement are here thoroughly presented. A comprehensive account is given of the theoretical motivation and interpretation. The focus is placed on the description and development of the experimental technique. The measurement has been a long-sought goal within the field of experimental high energy physics, which is now accomplished.

The oscillation search and measurement enterprise was an unique and enduring experience. This monograph stems from the author's doctoral dissertation, presented to the Physics Department of the Massachusetts Institute of Technology. The research work was carried out at the CDF experiment, in Fermilab. From the first steps of sensitivity projections of what might be achievable, to finally observing such beautiful and unprecedented results. There were long and intense years in between. I'll remember in particular the many excitements, challenges, and breakthroughs along the way shared with my closest collaborators. The measurement itself is the fruit of a collaborative work of many, who were directly or indirectly involved in the multiple aspects contributing to the analysis of the data, or who participated in the construction, development, and operation of the CDF detector and the Tevatron accelerator.